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DESIGN DEFINITION STUDY OF A LIFT/CRUISE FAN TECHNOLOGY V/STOL AIRCRAFT

VOLUME II ADDENDUM 2

PROGRAM RISK ASSESSMENT

BY
V/STOL ADVANCED ENGINEERING

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SUMMARY AND CONCLUSIONS

This report presents the results of a risk assessment study conducted on two of the technology aircraft described in Report MDC A3440, Volume II: New Airframe and Sabreliner. It was determined that both aircraft would have a "Low to Minor" risk in achieving the program objectives. These results also apply to the other configurations; i.e., Composite and Voodoo, because the major contributors to risk were the newer technology items that are essentially common for all.

The aircraft system components were reviewed and assessed for risk based on: 1) complexity relative to state-of-the-art, 2) manufacturing and qualification testing, 3) availability and delays, and, 4) cost/schedule impact. These assessments were based on five risk nomenclatures: low, minor, moderate, high, and extreme. It was determined that only the first three ratings were applicable and their definition is as follows:

- LOW - Fully developed
- MINOR - Current state-of-the-art; significant testing but not fully developed
- MODERATE - Feasibility well established but limited test experience; no serious difficulties expected.

Each aircraft system was then assigned an overall risk rating depending upon its contribution to the capability of the aircraft to achieve the performance goals of Attachment I to the Statement of Work. This risk rating was then modified to account for any excess performance margin provided by the MCAIR designs. The New Airframe and Sabreliner performance margins, as discussed in Report MDC A3440, Volume II, are illustrated in Figures 1 and 2.

The slightly lower Sabreliner performance margin is due to the restricted flight envelope, the fixed landing gear and internal fuel capacity. The Sabreliner with retractable gear and allowed to fly at its best speed and altitude would reflect performance margins similar to the New Airframe. These significant margins, inherent with the MCAIR three gas generator/three fan propulsion system, are major modifiers to risk assessment of both aircraft.

The estimated risk and the associated key system and performance areas are tabulated below. The risks are relative to current state-of-the-art and modified by design and performance margins.

FIGURE 1
AIRCRAFT PERFORMANCE MARGINS

	Reqmt \ Aircraft	Sabreliner	New Airframe
VTOL CIRCUIT	∿30 Min	37	39
	∿ 5 Circ	7	8
STOL CIRCUIT	∿60 Min	49	63
	∿11 Circ	10	13
STO CRUISE/ENDURANCE	2 hr T.O.S.	2.7	4.2

o VTOGW Limited to 28,000 lb for Hover Safety
o Payload = 2500 lb

FIGURE 2
ATTITUDE CONTROL POWER MARGINS

	Percent of Guideline Requirements		
	Roll	Pitch	Yaw
New Airframe	230	350	240
Composite	250	300	210
Sabreliner	200	275	175

SYSTEMS RISK AREAS

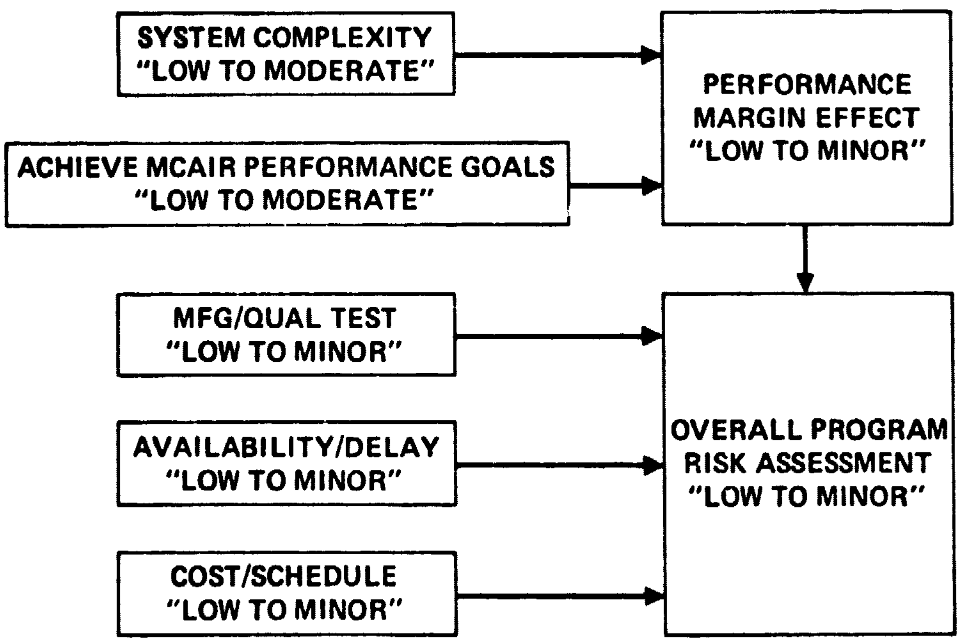
System	Key Areas	Program Risk
Propulsion	Thrust Vectoring; Nozzle Area Control	Minor
Flight Control	Attitude Control, Systems Interfacing	Low
Flight Control Avionics	Redundancy Management	Minor

PERFORMANCE RISK AREAS

Category	Key Areas	Risk Rating
Handling Qualities	Ground Effects; Engine-Out Control	Low to Minor
Stability	Hover, Low Speed and Cruise	Minor
Performance	Attachment I Goals	Low to Minor

The overall risk rating for system complexity as related to MCAIR design goals was determined to be "Low to Moderate" with the "Moderate" rating being associated with the Flight Control, Propulsion and Flight Control Avionics. The risk rating for aircraft performance capability was also "Low to Moderate" when related to MCAIR performance goals. These risk ratings were then modified based on the performance margins available and the resulting rating was "Low to Minor" for achieving the Attachment I requirements. The areas of manufacturing/qualification testing, availability/delay and cost/schedule impact were assessed a rating of "Low to Minor". The overall program rating related to Attachment I of the Statement of Work goals was estimated to be "Low to Minor" and is illustrated in Figure 3.

FIGURE 3
PROGRAM RISK ASSESSMENT



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SYMBOLS AND ABBREVIATIONS

ACS	Active Control System
A/C	Aircraft
AC	Alternating Current
Av/Del	Availability/Delay
A/F	Airframe
AM	Amplitude Modulation
CFE	Contractor Furnished Equipment
Cir	Circuits
DC	Direct Current
ETaC	Energy Transfer and Control
ft	feet
G.E.	General Electric
Gen.	Generator
GFE	Government Furnished Equipment
hr	Hours
IFF	Identification Friend or Foe
L/C	Lift/Cruise
lb.	Pounds
L.H.	Left Hand
Man	Manufacturing
MCAIR	McDonnell Aircraft Company
Min	Minutes
PGM	Program
Psi	Pounds per square inch
Qual	Qualification Testing
R&D	Research and Development
R.H.	Right Hand
Sabr	Sabreliner
SCM	Signal Conversion Mechanism
S/O	Shut Off
STO	Short Take-Off
SYS	System
T	Technology
T.O.S.	Time On Station
TRM	Thrust Reduction Modulation

T/W	Thrust to Weight
UHF	Ultra High Frequency
Vol	Volume
V/STOL	Vertical/Short Takeoff and Landing
VTO	Vertical Takeoff
VTOGW	Vertical Takeoff Gross Weight
W.T.	Wind Tunnel

1. INTRODUCTION

The objective of this Risk Assessment study was to determine the potential risks of developing two V/STOL technology aircraft defined as New Airframe and Sabreliner. This report defines the risk and presents the rationale and procedures used in the study. Risk is defined as the probability that a desired event will not be attained as planned by following the present or postulated course of action.

The assessment consisted of five tasks:

1. An evaluation of complexity and identification of potential risk items relative to the state-of-the art.
2. An evaluation of the potential risk to achieve the performance goals and guidelines of Attachment I of the Statement of Work.
3. Discussion of potential risk associated with the manufacturing and qualification testing.
4. Discussion of the risk associated with the availability and delays in delivery of necessary materials and off-the-shelf components.
5. A discussion of the probable cost trends and schedule impact of items judged to have a potential cost escalation risk.

The general arrangement of the New Airframe designed for the technology aircraft is shown in Figure 4, and that of the Sabreliner is shown in Figure 5. The three fans and three gas generators are interconnected into a duct and valve system identical in concept for both aircraft. The thrust vectoring and control systems are also essentially identical.

Achievement of low risk in new design is a growth process highly sensitive to the degree that design is guided and verified by both development and reliability testing. Further, wherever existing systems, equipment, and components meeting or exceeding design requirements can be effectively utilized, risk can be significantly reduced through judicious selection and careful review plus elimination of known functional failure modes or their effects. Alternatively, selection of equipment whose design capabilities will be exceeded in a new application increases risk, the degree depending on the amount of encroachment on safety factors, the nature of modifications, the duty cycles involved, and the sensitivity of the program's objectives to the particular items. Trading design characteristics of one type for another would also normally increase risk but probably to a lesser amount.

The risk assessment summarized in this report included the following elements:

- Evaluation of configuration complexity
- Determination of systems relative importance

FIGURE 4
NEW AIRFRAME

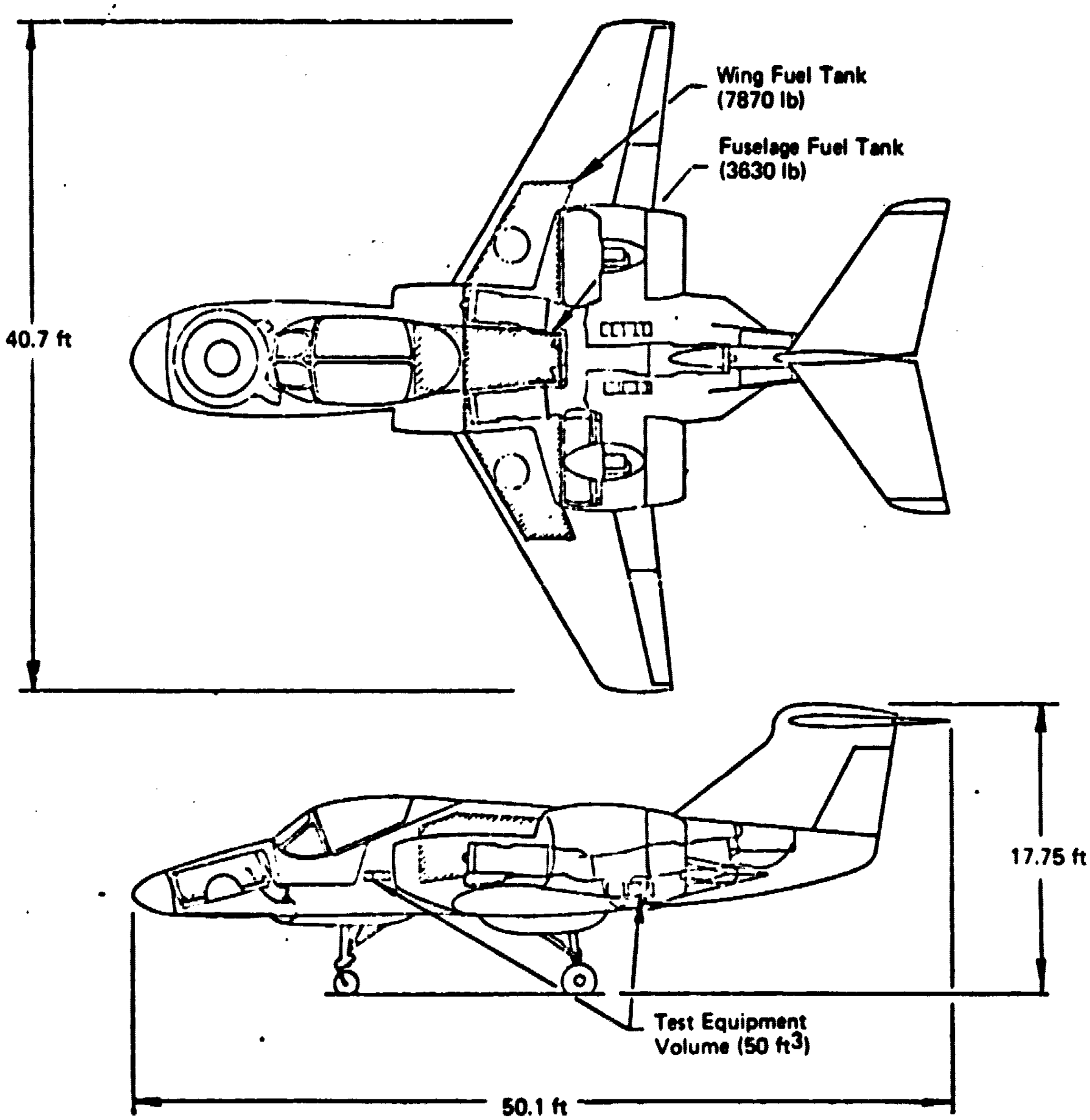
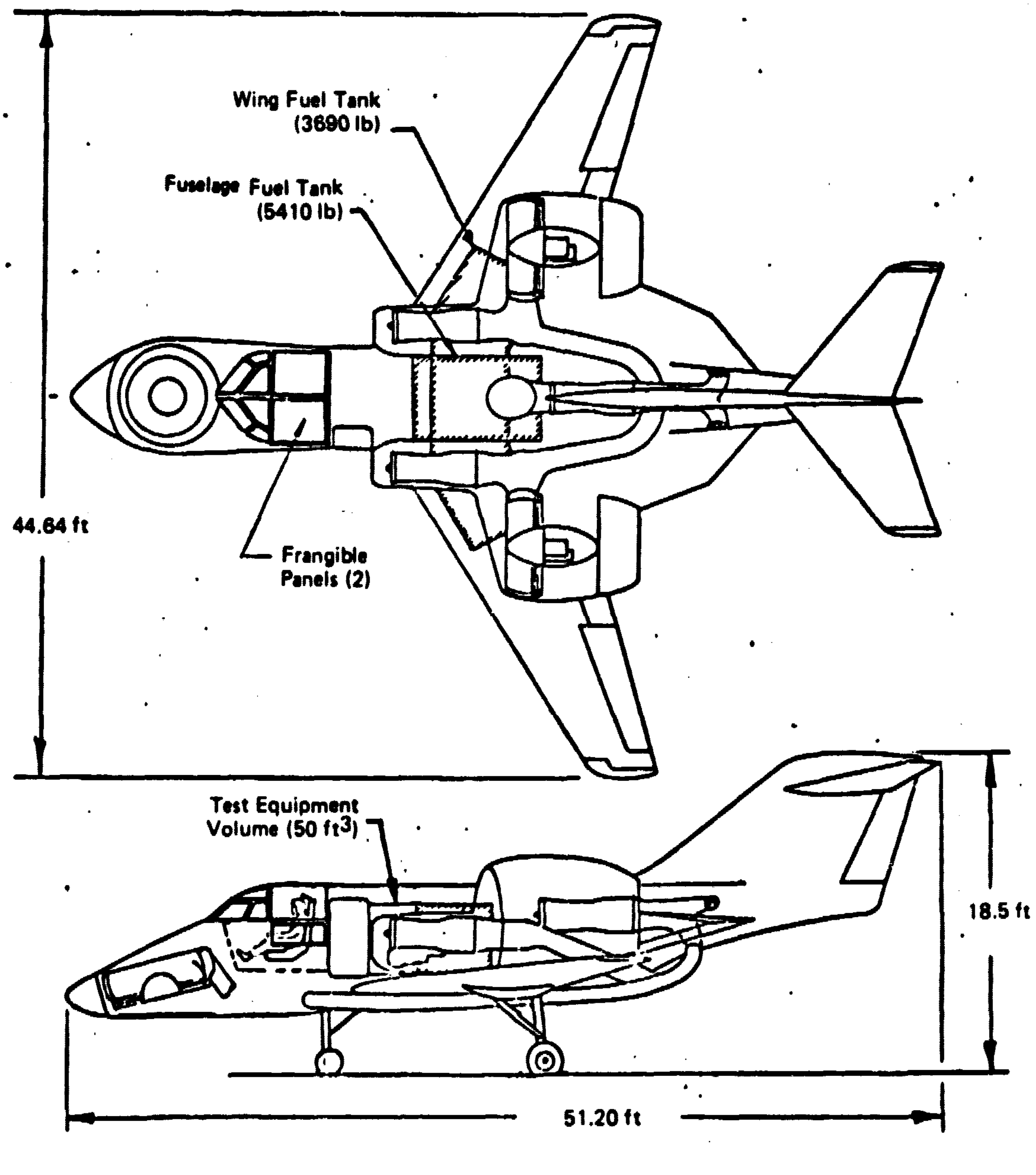


FIGURE 5
MODIFIED SABRELINER (T-39)
WITH EJECTION SEATS



- o Estimate of environmental capabilities
- o Examination of systems and component interfacing
- o Comparison of systems and components with state-of-the-art
- o Establishment of basic system risks
- o Determination of basic program technological risk
- o Potential manufacturing and testing risks
- o Impact of probable cost trends and schedules
- o Effect of availability and delivery delays.

Each system was examined to determine the number of components, their complexity, and their functions relative to current state-of-the-art. In addition the number, type, and function(s) of systems and component interfacing were determined relative to current state-of-the-art. Capability of systems and corroborating information were then considered to determine margins over basic requirements. The depth of these evaluations was consistent with the constraints of time and funding. Systems were then reviewed to determine the level of design and operating experience of similar items; i.e., relationship to state-of-the-art, and how critical the items were.

In performing the risk assessment, each known component was viewed from five different viewpoints:

- o Quantity
- o Physical complexity
- o Functional complexity
- o State-of-the-art technology
- o Environment.

These viewpoints were then combined in assessing component and system risks in four categories:

- o Technology (complexity relative to state-of-the-art)
- o Manufacturing
- o Qualification testing
- o Availability and delay.

Technology was then modified by design margins and, with the remaining categories, resolved into an assessment of the risk in achieving program objectives. Results showing unmodified risk in each category for each component are shown in Appendix A. In judging the degree of risk related to any item, five general categories of risk were used; these are shown and defined in Figure 6.

FIGURE 6
RISK NOMENCLATURE

Rating	Definition
Low Risk	o Fully developed o In use on current aircraft o Many operating hours/cycles in similar environment
Minor Risk	c Current state-of-the-art; significant testing but not fully developed
Moderate Risk	o Feasibility well established but limited test experience; no serious difficulties expected
High Risk	o Similar to programs having serious difficulties
Extreme Risk	o Quantum advance o Feasibility unknown o High number of serious difficulties anticipated but not well defined

2. CONFIGURATION COMPLEXITY RELATIVE TO STATE-OF-THE-ART

The New Airframe and Sabreliner were reviewed to the lowest detail available to determine system and component complexity relative to the present day state-of-the-art. The design details are consistent with the current phase of the development cycle. Systems for both aircraft were determined to be well within the state-of-the-art except for minor deviations in the Propulsion, Flight Control and Avionics systems. Initially systems were analyzed from the viewpoint of meeting MCAIR defined design goals. These risk assessments were then modified based on the design and performance margins discussed in Report MDC A3440, Volume II, to determine overall program risk. The system risk ratings are summarized in Figure 7.

This task consisted of review of systems and elements from the viewpoints of quantity, physical complexity, functional complexity, design state-of-the-art and environment. A tabular summary of these risk ratings are presented in Appendix A. Those components and systems contributing risks greater than "Minor", based on MCAIR goals, are summarized in Figure 8. The Flight Control and Propulsion systems were reviewed in detail from performance viewpoints; the results are summarized in Figures 9 and 10. Each of the aircraft systems are discussed in the following paragraphs relative to state-of-the-art. These discussions apply to both aircraft except as noted.

Airframe complexity of both aircraft is considered "Low" risk and within the state-of-the-art of current aircraft. Provisions for incorporation of the forward fan and the ETaC system pose no unusual problems and may be compared to a conventional three turbofan engine aircraft. For the Sabreliner, the wing poses a slight additional risk in repositioning the main landing gear outboard, but is well within the state-of-the-art. The Sabreliner is of slightly greater risk which is inherent with any substantial airframe modification and uncertainty of the aircraft's condition due to prior flight experiences.

Cockpit system is "Low" risk state-of-the art complexity for both configurations. The optional Sabreliner modification to accommodate ejection seats is also considered "Low" risk due to use of existing components.

Landing Gear systems are also well within state-of-the-art complexity and a "Low" risk item for both aircraft, since they are existing components from the A-4 aircraft. The fixed gear on the Sabreliner configuration presents slightly less risk than the retractable gear of the New Airframe configuration.

FIGURE 7

DESIGN MARGIN EFFECTS ON RISK

SYSTEMS	RISK VS MCAIR GOALS	DESIGN/PERFORMANCE MARGIN	NET RISK
Airframe	Low	Normal	Low
Cockpit	Low	Normal	Low
Landing Gear	Low	Normal	Low
Flight Control	Moderate	Excess Control Power/Redundancy	Low
Propulsion	Moderate	Excess T/W	Minor
Air Conditioning/Pressurization	Low	Normal	Low
Electrical	Low	Redundancy	Low
Lighting	Low	Normal	Low
Hydraulic	Low	Redundancy	Low
Fuel	Low	Normal	Low
Oxygen	Low	Normal	Low
Instruments	Minor	Normal	Minor
Avionics	Moderate	Redundancy	Minor

Ratings apply to both aircraft

FIGURE 8
COMPONENT COMPLEXITY RISK RELATIVE TO STATE-OF-THE-ART

FLIGHT CONTROL	Risk
Yaw Control Actuation, Nose Fan	Moderate
Interfaces, Nose Fan Control	Moderate
Yaw Control Actuation, L/C Fan	Moderate
Thrust Vectoring Nozzle Actuation	Moderate
Interfaces, L/C Fan	Moderate
PROPULSION	
ETaC Ducting and Valves	Moderate
Thrust Vectoring Nozzle	Moderate
AVIONICS	
Redundancy Management	Moderate

FIGURE 9
RISK ASSESSMENT
FLIGHT CONTROL RELATED TO MCAIR GOALS

Technology Item	Existing Technology	Development Test	Aircraft Performance Sensitivity	Estimated Risk	
				New Airframe	Sabreliner
Control Law Development	Model 253 Simulation Results	Man-in-the-Loop Flight Simulation	High	Minor	Minor
Powered Lift Control System Development	J97/ETaC Full Scale Test Results	ETaC Development and Full Scale Propulsion System Integration Tests and Flight Simulation	Moderate	Moderate	Moderate
Motion Sensors Development	F-4 (SFCS), F-15, F-16, Space Shuttle	Wind Tunnel Tests, System Integration Tests, and Simulation	Moderate	Minor	Minor
Active Control System Development	F-4 (SFCS), F-15, F-16, Space Shuttle, NASA F-8 Program	Simulation and System Integration Tests	High	Minor	Minor
Thrust Vectoring System Development	MCAIR/NASA Development Test Results	36" Thrust Vectoring Tests	High	Moderate	Moderate
ETaC System Development	J97 ETaC Test Results	[illegible]ld Flow Tests and [illegible]itional Full Scale [illegible] Tests	High	Minor	Minor

FIGURE 10
RISK ASSESSMENT
PROPULSION SYSTEM RELATED TO MCAIR GOALS

TECHNOLOGY ITEM	EXISTING TECHNOLOGY	DEVELOPMENT TEST	PERFORMANCE SENSITIVITY	ESTIMATED RISK	
				NEW AIRFRAME	SABRELINER
Gas Generator Inlet Design for high performance and Flow Field Insensitivity.	XV-5, Harrier, NASA & MCAIR reingestion test	o Static Inlet (Unpowered) o Hi-Speed W.T. (Unpowered) o Powered Model In Ground Effect o Tech. A/C Flt. Tests	High	Minor	Minor to Moderate
Lift Fan Inlet Design for high performance and Flow Field Insensitivity	XV-5, Numerous NASA Large Scale powered Wind Tunnel/A/C Installation tests MCAIR 193, Model 253, Supersonic Fan Powered Test	o Unpowered Static & Low Speed Model Tests o Powered Static & Low Speed Model Tests o Tech. A/C Flt Tests	High	Minor	Minor
Lift Cruise Fan Inlet Design for high performance and Flow Field Insensitivity	DC-10, Model 260 Model Tests (Exploratory Tests)	o Unpowered Static, Low & High Speed Model Tests o Powered Static, Low & High Speed Model Tests o Tech A/C Flt. Tests	High	Minor	Low
Lift Fan Louver System high thrust coefficient and vectoring efficiency	XV-5, Numerous NASA GE & MCAIR Large & Small Scale Powered Model & Windtunnel Tests	o Small Scale Static Tests o 36"-1.3 FPR-LF336 Fan Powered Tests o Tech A/C Flt. Tests	High	Minor to Moderate	Minor to Moderate
Thrust Vectoring Nozzle Design for efficient vectoring and cruise performance	Numerous MCAIR Screening & Development Tests 36"-1.3 FPR LF336 NASA Funded (MCAIR) Fan Powered Tests in Progress	o Phase II of 36"-1.3 FPR LF336 Fan Powered Tests o Tech A/C Flt Tests	High	Low to Minor	Low to Minor
Interconnect Ducting Design for Efficient gas transmission	XV-5A Flt. Tests Full Scale MCAIR ETaC Test, Boilerplate Single wall & Composite Subscale Composite Including proven survivability	o Small Scale (Cold Flow) Complete Duct System Tests o Full Scale ETaC Duct Tests o Tech A/C Flt. Tests	Moderate	Minor to Moderate	Minor to Moderate
ETaC Valve Design to Achieve attitude control requirements	Numerous Valve Press. Loss Tests MCAIR Full SCale ETaC-Valve Tests Subscale MCAIR Tests	o Subscale Valve Screening Tests o Small Scale (Cold Flow) Complete Duct/Valve Tests o Full Scale ETaC/Valve Tests o Tech A/C Flt. Tests	Low	Minor	Minor

Flight Control system was initially rated "Minor" to "Moderate" risk; however, control margins for the New Airframe of 230, 360 and 240 percent of roll, pitch and yaw requirements, respectively, effectively reduce the risk to a "Low" rating relative to effect on program risk. Similar Sabreliner control margins are 200, 280 and 170 percent, respectively. Generally, risk is attributed to system size, complexity, complexity of interfacing and the amount of testing required to achieve reasonable confidence. No appreciable difference exists between the two aircraft configurations. System redundancy minimizes the risk to the program from a safe flight viewpoint.

Anticipated development areas are control law derivation, system mechanization, Active Control System (ACS) design and derivation of flow paths and local flows for central air data computer probes. Detailed simulation runs and three-degree-of-freedom rig tests will serve to reduce risk. A summary of the flight control system risk assessment as related to MCAIR goals is shown in Figure 9.

Propulsion system is more complex than conventional aircraft applications due to integration/interfacing of control elements and is rated "Moderate" risk. The Sabreliner configuration has higher risk regarding lift cruise engine reingestion because the inlet length was reduced to provide cabin access. The vectoring range/efficiency of the forward fan louver system may have slightly less risk than the New Airframe because of nose landing gear positioning. The New Airframe was assigned a higher risk in the following areas primarily due to the high speed envelope:

- o Fan inlets for high speed cruise performance
- o Lift engine inlet location
- o Thrust vector nozzle high speed cruise thrust coefficient.

A summary of the propulsion risk assessment related to MCAIR goals is shown in Figure 10.

Environmental Control system complexity lies completely within the state-of-the-art and is "Low" risk; both the New Airframe and Sabreliner configurations will use the same system.

Electrical Power system has low complexity and is rated "Low" risk. Both aircraft have similar systems.

Lighting system is a very simple system for both aircraft and is rated "Low" risk.

Hydraulic Power system is of the conventional type using existing components and is rated "Low" risk.

Fuel system and Oxygen system consist of typical state-of-the-art complexity for both aircraft, and are rated "Low" risk.

All but five items are "Low" risk/state-of-the-art complexity in the Instrument system. The stability augmentation panel is slightly more complex than state-of-the-art and rated as "Minor" risk. Four items (vector angle indicator, angle of attack, fan vibration/amplitude and fan RPM) are considered "Minor" risk because of required modifications or being in current development.

Avionics for the Flight Control system is rated "Moderate" risk related to MCAIR design goals due to the redundancy management area. Other key areas such as computers, monitoring and interfaces are rated "Minor" risk. The remaining system elements are rated "Low" risk. The overall system rating when converted to program risk is changed to "Minor" due to inherent design margins and use of similar/identical critical components which are either in use or being developed for programs which may precede the technology demonstrator.

Avionics equipment was carefully chosen to minimize cost and risk to program objectives. The quantity and complexity are consistent with the technology program objective - no "mission" avionics are carried. For example, communications, identification and radio navigation equipment are minimums for close-to-field operations and are consistent with safe flight.

3. PERFORMANCE RISK

The aircraft were evaluated to determine the potential risk in achieving the performance goals and guidelines of Attachment I to the Statement of Work. The initial step was to ascertain the risk for the performance elements involved as related to state-of-the-art. These risk estimates were then modified due to the available performance and control margins described in Report MDC A3440, Volume II, to establish the risk associated with meeting the specified program goals. A summary of these risks by element is illustrated in Figure 11. The risk in achieving the overall performance goals is rated "Low to Minor". The elements associated with the risk analysis are discussed in the following paragraphs.

Handling qualities of the aircraft are dependent on the attitude control power and system response. Excess control power is available and the ETaC/TRM redundancy provides for aircraft safety, as discussed in Volume II. Adequate control response is available for both powered lift and aerodynamic flight. The key elements analyzed were: thrust modulation, ACS, ground effects, gyroscopic moments, crosswind trim, control surface effectiveness, and trim moment balance. This area of attitude control power for powered lift was rated as "Minor to Moderate". After consideration of the control power margin available, the risk was rated "Low to Minor". The flight path control power analysis resulted in the same risk rating as the attitude control power. Elements analyzed were: engine out T/W effects, acceleration capability, ground effects, stall characteristics, and control system effectiveness.

The aircraft stability characteristics were assessed for hover, low speed, and cruise conditions and the estimated risk is "Minor". Elements considered in evaluating the stability were: ACS, ground effects, surface effectiveness, yaw-roll coupling in transition, drag, stall patterns, post stall roll characteristics, angle of attack stability, and directional stability.

V/STO performance capabilities were assessed to be "Minor" on the New Airframe and "Minor to Moderate" for the Sabreliner. The Sabreliner risk rating is slightly higher due to the unknowns associated with the fan nacelle/wing integration. This rating would be improved after appropriate wind tunnel tests. The elements considered were: vector system deflection rate and schedule, climb-out gradient for both normal and engine out, ground effects, powered induced lift, and stabilator effectiveness.

FIGURE 11
POTENTIAL RISK TO ACHIEVE GUIDELINE GOALS

Performance Item	Existing Technology	Development Test	Estimated Risk MCAIR Goals		Performance Margins	Estimated Risk Guideline Goals	
			New A/F	Sabr.		New A/F	Sabr.
Powered Lift Handling Qualities Attitude Control Power Flight Path Control Power	o NASA/MCAIR R&D W/T Models Simulation XV-5 o G.E. R&D	W/T Model Tests ACS Bench Test Simulation V/STOL Stand	Minor to Moderate	Minor to Moderate	Excess Control Power Available per Vol II	Low to Minor	Low to Minor
Hover Stability Low Speed Stability Cruise Stability	Harrier XC-142 VAK-191B	W/T Model Tests ACS Bench Tests Simulation	Minor	Minor	Normal	Minor	Minor
V/STO Performance	Harrier XV-5 NASA/MCAIR R&D	W/T Model Tests ETaC Tests Simulation	Minor	Minor to Moderate	Excess T/W	Low	Minor
Conversion	Harrier XV-5	W/T Models Simulation ACS Bench	Minor	Minor	Normal	Minor	Minor
Mission Performance VTOL Circuits STOL Circuits Cruise/Endurance Time	State-of-the-Art	W/T Model Tests Hi Speed/Low Speed	Low to Minor	Minor	As Presented in Vol II	Low	Low to Minor

Conversion characteristics were assessed to be a "Minor" risk for both aircraft. A speed higher than the 160 knots specified for the Sabreliner was considered to assure adequate velocity overlap in conversion. The elements considered were: buffet onset, lift coefficients, vectoring efficiencies, velocity overlap, power effects, and stabilator effectiveness at conversion speed.

The mission performance demonstration capabilities were assessed as "Low" risk for the New Airframe due to the excess performance available for the VTO circuit, STO circuit, and cruise/endurance missions. The Sabreliner was rated "Low to Minor" because of a lower performance margin. This rating would be reduced to "Low" by using a retractable gear and flying at optimum speed and altitude. This change should be considered for the Sabreliner.

4. MANUFACTURING AND QUALIFICATION TESTING

This task was to assess the potential risk associated with the manufacturing and qualification testing of the components identified by Task 1 and shown in Figure 8. All of the components were rated "Low to Minor" risk except the thrust vectoring nozzle and the ETaC ducting which were rated "Moderate".

The forming of the thrust vectoring nozzle poses moderate difficulty because of the combination of size and materials (titanium and honeycomb structure). MCAIR is well experienced with fabrication of smaller parts made of these materials and anticipates no serious problems.

The "cool wall" metal duct design is considered slightly higher than state-of-the-art due to assembly techniques. The expansion section is a bellows which slightly exceeds state-of-the-art fabrication techniques. These items could be reduced to a "Minor" risk rating if a composite duct was used which required no bellows. The composite duct is currently in development.

No particularly difficult problems are expected in qualification testing of the above items, but the extensive interface testing creates more opportunity for test difficulties. The ratings apply only to the present time when practically all development testing lies ahead. As testing proceeds, risk will diminish as system characteristics are established with more certainty.

Qualification testing of the ducting poses no unusual or difficult problems and is considered "Minor" risk.

Testing of the thrust vectoring nozzle is rated "Moderate" risk because of the functional complexity. No unusual problems are anticipated since subscale and full scale boiler plate tests will provide basic experience well ahead of qualificating testing.

The austere flight test program creates some risk relative to program objectives. The risk pertains to completing the program within the basic constraints of time and funding, and in this context is highly sensitive to annoyance type failures and problems which in a lengthier program could be more easily absorbed.

The risk ratings for manufacturing and qualification testing of the components identified in Task 1 are summarized in Figure 12. Risk ratings for all components are shown in detail in Appendix A. Risk ratings were also determined for all systems and are summarized in Figure 13.

FIGURE 12
MANUFACTURING AND QUALIFICATION
TESTING RISK

	Manufacturing	Qualification Testing
FLIGHT CONTROL		
ETaC Control	Minor	Minor
Yaw Control Actuation, Nose Fan	Minor	Low
Interfaces, Nose Fan Control	Minor	Low
Yaw, Control Actuation, L/C Fan	Minor	Minor
Thrust Vectoring Nozzle Actuation	Minor	Minor
Interfaces, L/C Fan	Minor	Low
PROPULSION		
Fwd. Fan Louvers Performance	Minor	Minor
ETaC Ducting & Valves	Moderate	Moderate
Thrust Vectoring Nozzle	Moderate	Moderate
AVIONICS		
Redundancy Management	Minor	Minor

FIGURE 13
SYSTEM MANUFACTURING AND QUALIFICATION TEST RISK

SYSTEM	NEW AIRFRAME		SABRELINER	
	MANUFACTURING	QUALIFICATION TEST	MANUFACTURING	QUALIFICATION TEST
Airframe	Minor	Low	Minor	Minor
Cockpit	Low	Low	Low	Low
Landing Gear	Low	Low	Low	Low
Flight Controls	Minor	Low	Minor	Low
Propulsion	Moderate	Moderate	Moderate	Moderate
Air Cond/Pressurization	Low	Low	Low	Low
Electrical	Low	Low	Low	Low
Lighting	Low	Low	Low	Low
Hydraulic Power	Low	Low	Low	Low
Fuel System	Low	Low	Low	Low
Oxygen	Low	Low	Low	Low
Instruments	Low	Low	Low	Low
Avionics	Minor	Minor	Minor	Minor

5. EFFECT OF AVAILABILITY AND DELIVERY DELAYS

None of the items reviewed in this study is estimated to have more than minor risk of delaying the program because of availability or delivery delays. The components, equipment, and material selected to construct all technology aircraft configurations are in general readily available, and therefore low risk relative to availability. Major airframe components such as the A-6 forward fuselage and horizontal tail should present no problems; likewise, availability of the A-4 landing gear has low risk, since both these aircraft have been produced in large quantity. In the case of the Sabreliner, which has also been produced in large numbers as the T-39, a "Minor" risk is anticipated. Further, the F-101 empennage presents no schedule problems. Airframes will utilize standard inventory sheet metal.

"Minor" risk exists in delivery of critical items in the ETaC Control, Lift/Cruise Fan interfaces, and flight control avionics. "Minor" risk is estimated for the lift fan assemblies and gas generators, both of which are GFE. With the broad choices of GFE and CFE off-the-shelf equipment available, and the operational design margins employed, schedule delay is considered a low probability.

A complete list of items showing potential risk of availability or delay is shown in Appendix A, Column AV/Del. The summary of the system effects are shown in Figure 14.

FIGURE 14
SYSTEMS AVAILABILITY/DELAY RISK

SYSTEM	NEW AIRFRAME AVAILABILITY/DELAY	SABRELINER AVAILABILITY/DELAY
Airframe	Low	Minor
Cockpit	Low	Low
Landing Gear	Low	Low
Flight Controls	Minor	Minor
Propulsion	Minor	Minor
Air Cond/Pressurization	Low	Low
Electrical	Low	Low
Lighting	Low	Low
Hydraulic Power	Low	Low
Fuel System	Low	Low
Oxygen	Low	Low
Instruments	Low	Low
Avionics	Minor	Minor

6. GENERAL COST TRENDS AND SCHEDULE IMPACT

Complex and/or high risk programs tend to depart from published schedules and estimated costs. Schedule delays are frequently the result of technical difficulties associated with the level of risk. Schedule delays affect overall program costs in several ways:

1. The direct cost of solving the particular technical problem.
2. The overhead costs remain relatively fixed and these costs continue to accumulate until particular functions have been completed.
3. Only a part of the personnel costs can be "shut off" when there is a technical delay. For example, some items in the design release process would be delayed by delays in wind tunnel tests. Personnel costs would increase in both design and wind tunnel tests since the number of people on a particular function can not be changed to meet every contingency. While some control is possible, continuity of effort requires a degree of personnel stability in order to solve challenging technical problems.
4. Unpredictable costs may be incurred in complex high risk programs when it is necessary to obtain the servi of specialists in new areas of technology.
5. The anticipated effects of inflation will tend to be more severe when programs are delayed and/or stretched out.

In recognition of the relations between risk, schedule delays and costs, the MCAIR approach has been conservative whenever possible. For example, existing components have been used wherever possible in flight control systems. Risk has been assumed only where it is essential achieving an airworthy technology aircraft.

The components, systems, and interfaces judged to have a potential risk of increasing cost o schedule in developing an airworthy technology aircraft are as follows:

- The Sabreliner airframe due to uncertainty of its condition is considered a "Moderate" risk.
- The flight control system for both aircraft due to the quantity of interfaces and required integration. This risk is rated "Moderate".

- The thrust vectoring nozzle due to its effect on performance is rated "Moderate" for cost and "Minor" for schedule. These ratings should reduce to "Low to Minor" after current planned testing by NASA is completed.

The airframe risk for the Sabreliner is primarily associated with the condition of the model and amount of work required to reposition the main landing gear outboard. It has been estimated that the work affected by the risk is a negligible amount and a small part of the total program cost. The planning costs are reasonable for the work anticipated. However, this portion of the costs could increase if there are unanticipated difficulties with the particular airframe and/or with the repositioning of the main landing gear. The schedule for this work is flexible enough to allow for reasonable difficulties. However, there is a moderate risk of schedule slippage if extensive structural rework should be required. Schedule slippage would cause indirect effects on other costs as previously discussed.

It is estimated that about 25 percent of the flight control system costs are directly affected by items which involve a moderate risk. As far as the total program cost is concerned, the highest risk is in schedule slippage. The cost estimates and schedules are considered reasonable for the risk anticipated. However, the planning costs do not include any contingency for schedule slippage.

The propulsion system is considered to be "Low" risk; however, there is a "Moderate" risk associated with the thrust vectoring nozzle. This risk is based on the uncertainty of functional coordination and response accuracies. The Large Scale Powered Model tests and Thrust Vectoring tests will be completed in the near future and these results will reduce the risk rating to "Low to Minor".

VOLUME II

ADDENDUM 2

APPENDIX A

COMPONENT RISK SUMMARY

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APPENDIX A

COMPONENT RISK SUMMARY

This appendix summarizes all systems and components that were reviewed in this study and shows risk ratings for them in four categories designated as follows:

Risk Category	Symbol
Technology	Tech
Manufacturing	Man
Qualification Testing	Qual
Availability/Delay	Av/Del

The technology category integrates five elements:

- o Quantity
- o Physical Complexity
- o Functional Complexity
- o State-of-the-art Technology
- o Environment

The functional complexity and state-of-the-art technology were considered most important.

Manufacturing risk relates only to manufacturing problems, the readiness of solution or unusualness of the item/state-of-the-art relative to manufacture.

Qualification test risk considers only the problems/solutions involved with the test. State-of-the-art here considered only the nature of the test and the tests themselves. All tests are included under this title.

Availability and delay pertains to potential risk of the item not being available at the scheduled time.

The meaning of the risk ratings assigned are as follows:

Rating	Definition
Low Risk (L)	o Fully developed. o In use on current aircraft o Many operating hours/cycles in similar environment
Minor Risk (M)	o Current state-of-the-art; significant testing but not fully developed
Moderate Risk (Mod)	o Feasibility well established but limited test experience; no serious difficulties expected

High Risk (H)	o Similar to programs having serious difficulties
Extreme Risk (E)	o Quantum advance o Feasibility unknown o High number of serious difficulties anticipated but not well defined.

SYSTEM	RISK							
SUBSYSTEM/ITEM	NEW AIRFRAME				SABRELINER			
	Tech	Man	Qual	Av/Del	Tech	Man	Qual	Av/Del
AIRFRAME	L	M	L	L	L	M	M	M
FUSELAGE	L	L	L	L	L	L	L	M
Basic Shell	L	L	L	L	L	L	L	L
Stiffeners	L	L	L	L	L	L	L	L
Forward Fuselage	M	M	L	M	M	M	L	M
Radome	L	L	L	L	L	L	L	L
Nose	L	L	L	L	L	L	L	L
Lift Fan Mount	M	L	M	L	M	L	M	L
Center Fuselage	L	M	L	L	L	M	M	M
Nose Gear Provisions	L	M	L	L	L	L	L	L
Wing Area	L	L	L	L	L	M	M	M
Fuel Provisions	L	L	L	L	L	M	L	L
Air Inlet Duct	M	M	M	M	M	M	M	M
Engine Mounts	L	L	L	L	L	L	L	L
Engine Provisions	L	L	L	L	M	L	M	L
Auxiliary Inlet Doors	L	L	L	L	L	L	L	L
Aft Fuselage	M	M	L	L	M	L	L	L
Fan Doors	M	L	L	L	M	L	L	L
Fan Area	M	L	L	L	M	L	L	L
Fan Nacelle	M	L	M	M	M	L	L	L
Mounts	M	L	L	M	M	L	L	M
3rd Engine Doors	M	L	L	L	M	L	L	L
3rd Engine Inlet	M	L	L	L	M	L	L	L
Tail Provisions	M	M	M	L	M	M	L	L
WING	L	M	L	L	L	L	L	L
Leading Edge	L	L	L	L	L	L	L	L
Torque Box	L	L	L	L	L	L	L	L
Trailing Edge	L	L	L	L	L	L	L	L
Fairing	L	L	L	L	L	L	L	L
Landing Gear Doors	L	L	L	L	L	L	L	L
VERTICAL TAIL	L	L	L	L	L	L	L	L
Leading Edge	L	L	L	L	L	L	L	L
Torque Box	L	L	L	L	L	L	L	L
Trailing Edge	L	L	L	L	L	L	L	L
HORIZONTAL TAIL	L	L	L	L	L	L	L	L
Leading Edge	L	L	L	L	L	L	L	L
Torque Box	L	L	L	L	L	L	L	L
Trailing Edge	L	L	L	L	L	L	L	L

SYSTEM	RISK							
SUBSYSTEM/ITEM	NEW AIRFRAME				SABRELINER			
	Tech	Man	Qual	Av/Del	Tech	Man	Qual	Av/Del
COCKPIT	L	L	L	L	L	L	L	L
Windshield	L	L	L	L	L	L	L	L
Canopy	L	L	L	L	L	L	L	L
Mechanism	L	L	L	L	L	L	L	L
Cockpit Provisions	L	L	L	L	L	L	L	L
Floor	L	L	L	L	L	L	L	L
Ejection Provisions	L	L	L	L	L	L	L	L
Seats	L	L	L	L	L	L	L	L
Consoles	L	L	L	L	L	L	L	L
Ejection Sequence	L	L	L	L	L	L	L	L
O_2 Installation	L	L	L	L	L	L	L	L
Fire Extinguish and Detection	L	L	L	L	L	L	L	L

SYSTEM / SUBSYSTEM/ITEM	RISK: NEW AIRFRAME Tech	Man	Qual	Av/Del	SABRELINER Tech	Man	Qual	Av/Del
LANDING GEAR	L	L	L	L	L	L	L	L
Control Valve	L	L	L	L				
Emergency Release Handle	L	L	L	L				
Wheels Warning Light	L	L	L	L				
Gear Position Indicators	L	L	L	L				
Gear Control Handle	L	L	L	L				
Nose Gear								
Steering Control Switch	L	L	L	L	L	L	L	L
Forward Door Latch Cylinder	L	L	L	L				
Shock Strut	L	L	L	L	L	L	L	L
Steering Emergency Control Switch	L	L	L	L	L	L	L	L
Door Sequence Valve	L	L	L	L				
Door Filter	L	L	L	L				
Steering Amplifier	L	L	L	L	L	L	L	L
Flow Restrictor	L	L	L	L	L	L	L	L
Steering Control Valve	L	L	L	L	L	L	L	L
Actuating Cylinder	L	L	L	L				
Telescoping Mechanism	L	L	L	L				
Fork	L	L	L	L	L	L	L	L
Steering Actuator	L	L	L	L	L	L	L	L
Door Thermal Relief Valve	L	L	L	L				
Forward Door Latch Cylinder	L	L	L	L				
Rolling Assembly	L	L	L	L	L	L	L	L
Wheel	L	L	L	L	L	L	L	L
Tire	L	L	L	L	L	L	L	L
Main Gear								
Aft Door Latch Cylinder	L	L	L	L				
Door Sequence Valve	L	L	L	L				
Shock Strut	L	L	L	L	L	L	L	L
Actuating Cylinder	L	L	L	L				
Relief Valve	L	L	L	L				
Flow Restrictor	L	L	L	L				
Aft Door Actuator	L	L	L	L				
Drag Link	L	L	L	L	L	L	L	L
Forward Door Actuator	L	L	L	L				
Thermal Relief Valve	L	L	L	L				
Forward Door Latch Cylinder	L	L	L	L				
Rolling Assembly	L	L	L	L	L	L	L	L
Wheel	L	L	L	L	L	L	L	L
Tire	L	L	L	L	L	L	L	L
Drag Link Locking Cylinder	L	L	L	L	L	L	L	L
Wheel Brakes	L	L	L	L	L	L	L	L
Brakes	L	L	L	L	L	L	L	L
Control Valve	L	L	L	L	L	L	L	L
Selector Valve, (Manual)	L	L	L	L	L	L	L	L
Brake Reservoir	L	L	L	L	L	L	L	L
Master Brake Cylinder	L	L	L	L	L	L	L	L

SYSTEM	RISK							
	NEW AIRFRAME				SABRELINER			
SUBSYSTEM/ITEM	Tech	Man	Qual	Av/Del	Tech	Man	Qual	Av/Del
FLIGHT CONTROL	Mod	M	L	M	Mod	M	L	M
Cockpit								
Control Sticks	L	L	L	L	L	L	L	L
Linkage	L	L	L	L	L	L	L	L
Transducers	M	M	M	L	M	M	M	L
Pedal	L	L	L	L	L	L	L	L
Transducers	M	M	M	L	M	M	M	L
Transition Lever	L	L	L	L	L	L	L	L
Linkage	L	L	L	L	L	L	L	L
Front Fan								
Louvers, Inlet	M	M	M	L	M	M	M	L
Actuators	L	L	L	L	L	L	L	L
Linkage	L	L	L	L	L	L	L	L
Louvers, Yaw and Thrust Vector	M	M	M	M	M	M	M	M
Actuators	L	L	L	L	L	L	L	L
Linkage	L	L	L	L	L	L	L	L
SCM	L	M	L	M	L	M	L	M
Interfaces	M	M	M	M	M	M	M	M
ETaC Valves	M	M	M	L	M	M	M	L
Actuators	L	L	L	L	L	L	L	L
Linkage	L	L	L	L	L	L	L	L
SCM	L	M	L	M	L	M	L	M
L/C Fans								
ETaC Valves	M	M	M	L	M	M	M	L
Actuators	L	L	L	L	L	L	L	L
Linkage	L	L	L	L	L	L	L	L
SCM	L	M	L	M	L	M	L	M
Nozzle, Thrust Vector	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod
Actuators	L	L	L	L	L	L	L	L
TRM Door	M	M	M	M	M	M	M	M
Actuators	L	L	L	L	L	L	L	L
SCM	L	M	L	M	L	M	L	M
Yaw Vanes	Mod	M	M	M	Mod	M	M	M
Actuators	L	L	L	L	L	L	L	L
Linkage	L	L	L	L	L	L	L	L
SCM	L	M	L	M	L	M	L	M
Interfaces	M	M	M	M	M	M	M	M
ETaC Isolation Valve	L	M	L	M	L	M	L	M
Actuator	L	L	L	L	L	L	L	L
Linkage	L	L	L	L	L	L	L	L
Gas Generator Isolation Valves	M	M	L	L	M	M	L	L
Actuators	L	L	L	L	L	L	L	L
Linkage	L	L	L	L	L	L	L	L
Interfaces	M	M	M	M	M	M	M	M

SYSTEM SUBSYSTEM/ITEM	RISK NEW AIRFRAME Tech	Man	Qual	Av/Del	SABRELINER Tech	Man	Qual	Av/Del
FLIGHT CONTROL (Cont'd)								
Dump Valve	L	M	L	L	L	M	L	L
Actuator	L	L	L	L	L	L	L	L
Aileron								
Structure	L	L	L	L	L	L	L	L
Actuator	L	L	L	L	L	L	L	L
SCM	L	M	L	M	L	M	L	M
Linkage	L	L	L	L	L	L	L	L
Interfaces	L	L	L	L	L	L	L	L
Stabilator								
Structure	L	L	L	L	L	L	L	L
Actuator	L	L	L	L	L	L	L	L
SCM	L	M	L	M	L	M	L	M
Linkage	L	L	L	L	L	L	L	L
Interfaces	L	L	L	L	L	L	L	L
Rudder								
Structure	L	L	L	L	L	L	L	L
Actuator	L	L	L	L	L	L	L	L
SCM	L	M	L	M	L	M	L	M
Linkage	L	L	L	L	L	L	L	L
Interfaces	L	L	L	L	L	L	L	L
Flaps	L	L	L	L	L	L	L	L
Selector Valve	L	L	L	L	L	L	L	L
Actuators	L	L	L	L	L	L	L	L
Flow Dividers	L	L	L	L	L	L	L	L
Linkage	L	L	L	L	L	L	L	L
Active Control System	(See Avionics System)							

SYSTEM	RISK							
	NEW AIRFRAME				SABRELINER			
SUBSYSTEM/ITEM	Tech	Man	Qual	Av/Del	Tech	Man	Qual	Av/Del
PROPULSION	Mod	Mod	Mod	M	Mod	Mod	Mod	M
Gas Generator	L	L	L	M	L	L	L	M
Controls	M	M	M	M	M	M	M	M
Lift Fan	M	M	M	M	M	M	M	M
L/C Fans	M	M	M	M	M	M	M	M
Air Turbine Starter	L	L	L	L	L	L	L	L
Forward Fan Duct	Mod	Mod	Mod	M	Mod	Mod	Mod	M
Interconnect Duct	Mod	Mod	Mod	M	Mod	Mod	Mod	M
L/C Fan Duct	Mod	Mod	Mod	M	Mod	Mod	Mod	M
Duct Expansion Sections	Mod	Mod	M	M	Mod	Mod	M	M

SYSTEM	RISK							
	NEW AIRFRAME				SABRELINER			
SUBSYSTEM/ITEM	Tech	Man	Qual	Av/Del	Tech	Man	Qual	Av/Del
ENVIRONMENTAL CONTROL	L	L	L	L	L	L	L	L
Valve, Bleed Air S/O	L	L	L	L	L	L	L	L
Regulator, 18 psi	L	L	L	L	L	L	L	L
Valve, Relief 22-1/2 psi	L	L	L	L	L	L	L	L
Switch, Emergency	L	L	L	L	L	L	L	L
Valve, Emergency	L	L	L	L	L	L	L	L
Control, Flow Limiter	L	L	L	L	L	L	L	L
Heat Exchanger	L	L	L	L	L	L	L	L
Turbine, Cooling	L	L	L	L	L	L	L	L
Seal, Door, Air Tank	L	L	L	L	L	L	L	L
Regulator, Door Seal	L	L	L	L	L	L	L	L
H_2O Separator	L	L	L	L	L	L	L	L
Sensor, Water Separator	L	L	L	L	L	L	L	L
Valve, Flood Flow	L	L	L	L	L	L	L	L
Valve, Emergency Ram Air	L	L	L	L	L	L	L	L
Connector Ground Air Conditioner	L	L	L	L	L	L	L	L
Chamber, Mixing	L	L	L	L	L	L	L	L
Valve, Hot Air Mix	L	L	L	L	L	L	L	L

SYSTEM	RISK							
	NEW AIRFRAME				SABRELINER			
SUBSYSTEM/ITEM	Tech	Man	Qual	Av/Del	Tech	Man	Qual	Av/Del
ELECTRICAL	L	L	L	L	L	L	L	L
Generators	L	L	L	L	L	L	L	L
Panel	L	L	L	L	L	L	L	L
Line Contactor	L	L	L	L	L	L	L	L
Power Conversion								
Transformer/Rectifier	L	L	L	L	L	L	L	L
Essential Transformer/ Rectifier	L	L	L	L	L	L	L	L
Distribution								
AC Bus	L	L	L	L	L	L	L	L
DC Bus	L	L	L	L	L	L	L	L
Relay	L	L	L	L	L	L	L	L
Essential AC Bus	L	L	L	L	L	L	L	L
Essential DC Bus	L	L	L	L	L	L	L	L
Diodes	L	L	L	L	L	L	L	L
Circuit Breaker	L	L	L	L	L	L	L	L
Three Phase Monitor	L	L	L	L	L	L	L	L
Fuse	L	L	L	L	L	L	L	L

SYSTEM SUBSYSTEM/ITEM	RISK NEW AIRFRAME Tech	Man	Qual	Av/Del	SABRELINER Tech	Man	Qual	Av/Del
LIGHTING	L	L	L	L	L	L	L	L
Land, Taxi System	L	L	L	L	L	L	L	L
Position Light System	L	L	L	L	L	L	L	L
Anti-Collision System	L	L	L	L	L	L	L	L
Interior:								
Overhead Dome	L	L	L	L	L	L	L	L
Entrance	L	L	L	L	L	L	L	L
Flood-Consoles, Panels, Pedestal	L	L	L	L	L	L	L	L
Indirect - Cockpit	L	L	L	L	L	L	L	L
Utility - Cockpit	L	L	L	L	L	L	L	L
Emergency - Cockpit	L	L	L	L	L	L	L	L

SYSTEM	RISK							
	NEW AIRFRAME				SABRELINER			
SUBSYSTEM/ITEM	Tech	Man	Qual	Av/Del	Tech	Man	Qual	Av/Del
HYDRAULIC	L	L	L	L	L	L	L	L
Power Control Systems	L	L	L	L	L	L	L	L
Pump, Variable Displacement	L	L	L	L	L	L	L	L
Reservoir, Boot Strap	L	L	L	L	L	L	L	L
Filter Module	L	L	L	L	L	L	L	L
Filters	L	L	L	L	L	L	L	L
Relief Valves	L	L	L	L	L	L	L	L
Pressure Sensors	L	L	L	L	L	L	L	L
Contamination Sampling Valve	L	L	L	L	L	L	L	L
Pressure Indicator, Filter	L	L	L	L	L	L	L	L
Check Valves	L	L	L	L	L	L	L	L
Oil Cooler	L	L	L	L	L	L	L	L
Fill Valve	L	L	L	L	L	L	L	L
Drain	L	L	L	L	L	L	L	L
Ground Test Fitting	L	L	L	L	L	L	L	L
Plumbing	L	L	L	L	L	L	L	L
Switching Valves	L	L	L	L	L	L	L	L

SYSTEM / SUBSYSTEM/ITEM	RISK: NEW AIRFRAME Tech	NEW AIRFRAME Man	NEW AIRFRAME Qual	NEW AIRFRAME Av/Del	SABRELINER Tech	SABRELINER Man	SABRELINER Qual	SABRELINER Av/Del
FUEL	L	L	L	L	L	L	L	L
Sealant	L	L	L	L				
Bladders	L	L	L	L				
Pumps & Plumbing	L	L	L	L				
Valve, Vent	L	L	L	L				
Standpipe	L	L	L	L				
Valve, S/O, Manual	L	L	L	L				
Valve, S/O Level Control	L	L	L	L				
Valve, S/O Fuel Line	L	L	L	L				
Valve, S/O Engine Manifold	L	L	L	L				
Pumps, Fuel Transfer, Elect.	L	L	L	L				
Switch, Pressure	L	L	L	L				
Hydraulic Heat Exchanger	L	L	L	L				
Fuel Quantity Probe	L	L	L	L				
Pressure Relief	L	L	L	L				
Flow Transmitter	L	L	L	L				
Flame Arrest	L	L	L	L				
Valve, Drain	L	L	L	L				
Valve, Check, Fuel	L	L	L	L				
Valve, Check, Hot Air	L	L	L	L				
Adapter Assembly	L	L	L	L				
Crossfeed & Tank Selector Switch					L	L	L	L
Fuel Jettison Switch					L	L	L	L
Fuel Transfer Ejector					L	L	L	L
Left Hand Fuel Boost Pump					L	L	L	L
Right Hand Fuel Boost Pump					L	L	L	L
Tank Cross-Feed Valve					L	L	L	L
Fuel Jettison Level Control Float Switch					L	L	L	L
Pump Cross-Feed Valve					L	L	L	L
Left Hand Fuel Shut-Off Valve					L	L	L	L
Right Hand Fuel Shut-Off Valve					L	L	L	L
Pressure Switch					L	L	L	L
Check Valves					L	L	L	L
Fuel Jettison Valves					L	L	L	L
Vent Flame Arrestor					L	L	L	L
Single Point Refueling Level Control & Vent Valve					L	L	L	L
Dual Remote Control					L	L	L	L
Shut-Off Valve					L	L	L	L
Single Point Refuel Test					L	L	L	L
Receptacle					L	L	L	L
Fuselage Tank Refueling Level Control Valve					L	L	L	L
3rd Engine Fuel Boost Pump					L	L	L	L
3rd Engine Fuel Shut-Off Valve					L	L	L	L

SYSTEM	RISK							
SUBSYSTEM/ITEM	NEW AIRFRAME				SABRELINER			
	Tech	Man	Qual	Av/Del	Tech	Man	Qual	Av/Del
OXYGEN (Existing T-39)	L	L	L	L	L	L	L	L
High-Pressure Oxygen Storage Cylinder	L	L	L	L	L	L	L	L
	L	L	L	L	L	L	L	L
High-Pressure Filler Valve	L	L	L	L	L	L	L	L
Pressure Sensing Transmitter	L	L	L	L	L	L	L	L
Electrical Gage	L	L	L	L	L	L	L	L
Pressure Reducer	L	L	L	L	L	L	L	L
Pressure Regulator	L	L	L	I	L	L	L	L
Oxygen Mask	L	L	L	L	L	L	L	L
Flow Indicators	L	L	L	L	L	L	L	L
Ground Test Push Button	L	L	L	L	L	L	L	L
Manual Shutoff Valve	L	L	L	L	L	L	L	L

SYSTEM SUBSYSTEM/ITEM	RISK NEW AIRFRAME Tech	Man	Qual	Av/Del	SABRELINER Tech	Man	Qual	Av/Del
INSTRUMENTS	M	L	L	L	M	L	L	L
Attitude Indicator	L	L	L	L	L	L	L	L
Horizontal Situation Indicator	L	L	L	L	L	L	L	L
Mach Airspeed Indicator	L	L	L	L	L	L	L	L
Barometric Altimeter	L	L	L	L	L	L	L	L
Radar Altimeter	L	L	L	L	L	L	L	L
Vector Angle Indicator	M	L	L	L	M	L	L	L
Clock	L	L	L	L	L	L	L	L
Vertical Velocity Indicator	L	L	L	L	L	L	L	L
Flight Control System Panel	M	L	L	L	M	L	L	L
Turn & Slip Indicator	L	L	L	L	L	L	L	L
Accelerometer	L	L	L	L	L	L	L	L
Angle of Attack Indicator	M	L	L	L	M	L	L	L
Angle of Slip Indicator	L	L	L	L	L	L	L	L
Fan: Vibration Amplitude	M	L	L	L	M	L	L	L
Speed (RPM)	L	L	L	L	L	L	L	L
Engine: Speed (RPM)	L	L	L	L	L	L	L	L
Exhaust Gas Temperature	L	L	L	L	L	L	L	L
Fuel Flow	L	L	L	L	L	L	L	L
Oil Pressure	L	L	L	L	L	L	L	L
Flap Position Indicator	L	L	L	L	L	L	L	L
Landing Gear Position Indicator	L	L	L	L	L	L	L	L
Stabilator Trim Indicator	L	L	L	L	L	L	L	L
Hydraulic Control Panel	L	L	L	L	L	L	L	L
Magnetic Compass	L	L	L	L	L	L	L	L
Cabin Pressure Altitude	L	L	L	L	L	L	L	L
Pressure Control Panel	L	L	L	L	L	L	L	L
Low Airspeed Indicator	L	L	L	L	L	L	L	L
Standby Attitude Indicator	L	L	L	L	L	L	L	L

SYSTEM	RISK							
	NEW AIRFRAME				SABRELINER			
SUBSYSTEM/ITEM	Tech	Man	Qual	Av/Del	Tech	Man	Qual	Av/Del
AVIONICS	Mod	M	M	M	Mod	M	M	M
Communication, Radio Navigation & Identification								
UHF AM Transceiver	L	L	L	L	L	L	L	L
Intercomm	L	L	L	L	L	L	L	L
IFF TRansponder	L	L	L	L	L	L	L	L
TACAN	L	L	L	L	L	L	L	L
Antennas								
UHF/L Band	L	L	L	L	L	L	L	L
Transponder	L	L	L	L	L	L	L	L
Navigation								
Attitude & Heading	M	M	M	L	M	M	M	L
Magnetic Azimuth Detector	L	L	L	L	L	L	L	L
Air Data System								
Air Data Computer	M	L	L	L	M	L	L	L
Pitot Static Probe	L	L	L	L	L	L	L	L
Total Temperature Sensor	L	L	L	L	L	L	L	L
Low Velocity Airspeed System	M	M	M	M	M	M	M	M
Flight Control Computers								
Digital Processor	M	L	L	M	M	L	L	M
Digital Memory	L	L	L	L	L	L	L	L
Data Transfer	L	L	L	L	L	L	L	L
Signal Conditioning & Conversion	L	L	L	L	L	L	L	L
Signal Selection & Voting Devices	L	L	L	L	L	L	L	L
Cross Channel & In-Line-Monitors	M	L	L	L	M	L	L	L
Analog Microcircuits	L	L	L	L	L	L	L	L
Power Supply	L	L	L	L	L	L	L	L
Flight Control Software								
Development, Verification & Logistics Control	M	L	M	M	M	L	M	M
Computational Technique	M	L	L	L	M	L	L	L
Redundancy Management	Mod	M	M	M	Mod	M	M	M
Computer Synchronization	M	L	M	L	M	L	M	L
Sensors and Transducers								
Motion	L	L	L	L	L	L	L	L
Attitude	L	L	L	L	L	L	L	L
Air Data	M	L	L	L	M	L	L	L
Pilot Controls	L	L	L	L	L	L	L	L